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The use of cotton strips to indicate cellulose decomposition in the field

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0. Introduction

Variations in seasonal activity and of the type of soil profile must be considered in any comparison of field biological activity in soils on a range of sites. Measurements taken for one part of the profile at any one time can give erroneous comparisons. Simple and easily recorded test methods are needed, and these methods must cause minimal alteration of soil conditions and allow a quantitative assessment over a wide range of activity. For studies on decomposition, the colonization or disappearance of added substrates are frequently recorded. Ideally, a natural material should be used without added nutrient sources and, for a non-selective measure, the material should register decay caused by all members of the soil biota. Despite the obvious disadvantages, a standard artificial test substrate is frequently used.

Cellulose constitutes 70 % of the organic carbon compounds in plants and is therefore one of the more important components of the decomposition cycle. Cellulosic substrates placed in the soil have been assessed visually for their degradation, or the loss of dry weight measured. Delicate materials such as cellophane film (Went 1959; Tribe 1961), filter paper (Unger 1966) or lens tissue (Griffiths 1963) have been used in laboratory tests, but may disintegrate before being retrieved unless frequent visits can be made to a site. Dry weight loss of retrieved samples may be affected by mineral or organic contamination unless this contamination is removed from samples by chemical treatments (Rosswall 1974).

For these reasons, strips of cotton material were used and inserted vertically into the soils of a Pennine moorland and the rate of decomposition of these strips was assessed visually (Latter, Cragg and Heal 1967). The loss of tensile strength was later used in an attempt to find a quantitative measure of cellulose decomposition. This measure, which depends on the degradation of the cotton cellulose, is little affected by soil contamination. The method used to record tensile strength (TS) follows British Standard 2576 (Anonymous 1959) as far as possible.

The burial of test materials within soil has been widely used in the textile industry to test the resistance of materials to field exposure and the effectiveness of fungicides. Hueck (1960) and Hueck and Toorn (1965) discuss some theoretical aspects of the test and Schmidt and Rushmeyer (1958) refer to variability caused by soil characteristics. The method is included in an FAO publication (Anonymous 1967) for laboratory methods of soil microbiology, but has seldom been used for ecological work.

This paper describes the method used for comparisons of cellulose decomposition in the Tundra Biome of the International Biological Program (IBP) (Heal et al. 1975; Baker 1974), describes an experiment comparing TS loss with weight loss, and discusses the use and potential of the method.

1. The method

1.1. Material

A woven cloth was used because, even under wet soil conditions, it remains intact until extensive decomposition occurs. The cloth is also sufficiently flexible to conform to the soil structure and make close contact with soil particles. The thickness of the cloth was such as to avoid rapid disintegration but not to cause development of a micro-environment with a high moisture content. Any cloth can however act as a "wick", transporting water or nutrients from lower levels.

Cotton was selected because it is a natural fibre, is a non-degraded form of cellulose and has a higher percentage of cellulose than other natural fibres such as flax and jute. The cellulose in cotton is pure and of a highly ordered crystalline form composed of very long unbranched chains of glucan units (SELBY 1968; JEFFRIES et al. 1969) and is therefore slightly different to that in other plant materials, SELBY (1968) has shown that a complete enzyme complement is required for its attack. A method like this can only show potential activity, because the addition of any nutrient substrate will cause enrichment of organisms able to utilize it. It will also be selective for particular organisms though cotton does seem less selective than some other forms of cellulose. It is attacked by a wide range of micro-organisms, including fungi, bacteria, actinomycetes and yeasts (NIGAM et al. 1960; DESAI and PANDEY 1971; DENIZEL et al. 1974) and at later stages it may be ingested by fauna.

A non-degraded form of cotton cloth (unbleached calico in the loom state), was used which had not been bleached, mercerized or received other finishing treatments that might cause partial degradation of the fibres or protection from attack. It had, however, received the normal sizing treatments, with a starch base size and a tallow lubricant. A uniform cloth with a regular weave is also necessary. The material, 100 % cotton, 92.98 % α-cellulose, 7 oz/sq. yd (resp. 170 g/m^2), plain weave 60×60 20/20, was supplied by Hawkins Ltd., but this cloth, used until 1974, is no longer available from the manufacturers.

1.2. Recording of decomposition

Tensile strength rather than weight was used as the measure of decomposition for three main reasons. First, it can give a more sensitive measure of degradation than weight loss, since 0—100 % TS loss represents only 0—25 % weight loss; more accurate weight loss measurements are needed to detect the same level of decomposition and strips can be retrieved prior to disintegration at very low weight losses. Second, weight is more affected by mineral and organic soil contamination. Third, TS is the quicker measure to perform.

Analysis of cellulose content rather than total weight, would not be feasible for large numbers of samples.

TS loss, under normal field conditions, is largely caused by biological agencies, but also measures forms of degradation which are not true decomposition e.g. physical splitting of the fibrils, whether by biological or chemical agencies. Cotton can disintegrate with chemical treatment, e.g. acids (STAUDINGER and SORKIN 1937), but concentrations of such chemicals in normal soil conditions are too low to have an appreciable effect on the cotton. At the Pennine moorland site, strips placed in a biologically inactive bare peat site with *p*H 3.0—3.3, took 5 years to show any rotting, so the low *p*H of this site had no obvious short-term effect. HALLIWELL (1965) has shown that low concentrations of H_2O_2 and $FeSO_4$ can disintegrate cotton, and the lowest concentrations he used could occur in soils. At low temperatures, this reaction is slow, but in any case, H_2O_2 is produced as a result of biological processes and, as Halliwell points out, the reaction may well contribute to the normal microbial attack of cellulose. A fluidity test (SUI 1951, p. 295, HEAD and LUND 1969) could be used to assess chemical, as opposed to microbial, degradation of cotton.

1.3. Preparation and field placing of strips

Selvedges are removed from the cloth, and, with the weft strands in the long direction, strips 35×10 cm are torn from the cloth. The strips are boiled twice in water and rinsed well, using distilled water for the last rinse, to remove soluble nutrients added as size. Starch was significantly reduced, but was still the major remaining nutrient at levels of approximately 4 % (Table 1). Crude fat remained at a concentration of 0.5 to 1.0 %. After washing, the strips are laid on filter paper, dried, and placed between more sheets of filter paper, then wrapped in aluminium foil and sterilized in an autoclave at 121 °C for 15 minutes.

In the field, a spade or sharp knife is used to cut through the litter layer, where present, and, folding the lower 4 cms of the strip over the blade of a small straight spade the strip is carefully inserted vertically into the soil leaving 6 cms above the surface. On sites where underlying rock or stones impede insertion, a different method may be required. The aim is to minimise disturbance and to attain close contact between strip and soil. Where interference by larger grazing animals may occur the top of the strip can be secured to the soil, e.g. with a plastic rod.

To estimate the initial TS, a sample of 10 strips is retained as a control and given identical treatment apart from field placing. In the IBP work, some field controls were placed in the soil profile at the same time as test samples, but were immediately removed to assess errors due to stretching or damage of fabric during field placing.

1.4. Retrieval and measurement of tensile strength

Strips are retrieved after a significant decrease in tensile strength will have occurred, and before 85 % loss is reached, when strips are easily broken during retrieval. Figs. 11 and 12, and appendix in HEAL et al. (1974) could aid the estimation of suitable test periods for a site. Similar seasonal periods should be compared, or strips left out for a whole year. For most Tundra sites, the latter was possible, but, for more active sites, two or more sets of strips could be placed consecutively. Times taken for 50 % loss were between 30 and 480 days, but, in some Polar regions, may be longer than 10 years. In very active sites, e.g. in tropical conditions or in compost heaps (THAYSEN et al. 1939), total TS loss can occur within two weeks. Loss of tensile strength may be standardised to per unit time (day or year) or to the length of time required to reach 50 % loss. The pattern of decomposition with time, including occurrence of an initial lag period, may vary between soils, and under field conditions, normal seasonal variation is superimposed on this time sequence. For critical comparisons such effects could be examined for particular sites.

On retrieval, the position of the soil surface is marked on the strip. Using a long, sharp knife, vertical cuts are made in the soil extending from the original insertion lines and then at right angles so that the soil can be carefully removed from one face of the strip which is then gently lifted by hand. A detailed profile description can then be recorded. The strips are labelled and replaced between the sheets of filter paper in foil for return to the laboratory. Any storage at this stage should be at 0—2 °C. The strips are then washed to remove all loose soil, dried flat at room temperature and stored under dry conditions. Visual observations or photographs can be made at this stage. Washing and drying should be done as soon as possible after retrieval to minimize further decomposition.

Prior to TS measurement, strips are cut horizontally at 4 cm intervals from the soil level, following a cross thread, into a maximum of five pieces, and small, numbered, self-adhesive labels are placed at the ends of the pieces for identification. The pieces are placed between two blocks of wood against which they are frayed down to a standard 3 cm width using a wire brush. Since tensile strength is proportional to the width of the tested sample, results for samples of different width should be expressed as per mm width.

The standard size of unfrayed piece for textile testing is 5×20 cm (BS 2576). The reduced size of our test piece (4×10 cm) was a compromise to give a convenient strip width for field placing and several records with depth. Use of narrower pieces, including single threads, increases the error due to width variation or to localized points of high decomposition. For examination of closer depth intervals, a sequence of shorter field strips, placed horizontally, could be used.

Tensile strength varies with moisture content, e.g. for the cotton material used in this study, the tensile strength of wet and dry strips differed by 8 kg. Samples are therefore conditioned by oven drying at 50 °C (to give the required humidity of below 10 %), for 4 hours, and then placed in a humidity room or cabinet, at 20 °C with RH 65 %, for at least 24 hours. Tensile testing is carried out in the humidity room, or pieces are removed from the cabinet immediately before testing.

Table 1. Chemical analysis of control cotton

Treatment of cloth	Means % odw ± S.E.				
	Ash	N_2	Starch	Crude fat	Holocellulose
None	3.10 ± 0.09	0.17 ± 0.01	8.73 ± 0.9	0.74 ± 0.16	96.47 ± 0.26
Washed	1.93 ± 0.13	0.12 ± 0.03	4.27 ± 0.6	0.49 ± 0.19	98.16 ± 0.20
Washed and autoclaved	2.08 ± 0.43	0.13 ± 0.02	4.50 ± 0.3	0.86 ± 0.10	98.32 ± 0.29
F ratio for differences between treatments, df = 2,7	3.8	3.7	16.2**	1.7	14.5**

Methods as described in ALLEN et al. (1974), those used for starch and holocellulose could give a certain amount of "overlap".

Significance of F ratios in tables P = 0.05 *
P = 0.01 **
P = 0.001***

The tensile strength, i.e. the load to breaking point, can be measured on any standard machine with modification of the jaws where necessary. For the IBP studies, a Goodbrand machine, Vertical tensile tester for fabric, model L. (a) was used, with a rate of traverse of 10 cm/min. The longitudinal distance between the clamping positions was 5 cm. The jaws of any machine should clamp the material evenly along the grain and according to BS 2576, in order to obtain a correct tear and avoid slipping or shear.

For the statistical analysis of all initial results, the use of untransformed TS data was preferred. Missing values, through disintegration or absence of pieces, may be replaced by estimated values, if necessary (HEAL et al. 1974). Analyses of profile data must allow for the fact that results for each depth of a strip are not independent of each other.

2. Results of tensile strength tests

2.0. General remark

In this section a summary of some results is given to show the use of the method and the variability of results. The data used include those obtained in the IBP and other studies; the method was identical in all cases.

2.1. Within and between cloth variation

The mean tensile strength of 9 sets of ten control pieces, ranged from 26.0 to 27.6 kg with standard errors of 0.4 to 1.0 kg. It follows that differences in TS of less than 10 % from the mean are not detectable and a cloth showing more uniform characteristics would be an advantage. The TS of batches of cloth bought since 1963 were not significantly different ($F = 0.7$) nor were those for pieces taken in the warp and weft directions ($F = 0.05$).

2.2. Field control tests

Compared with fabric controls, field control strips usually showed a slight loss in TS of approximately 5 %, but, in certain soils, e.g. Signy Island, Antarctica, an increase in tensile strength occurred. This may result from a differential removal of wax, or from a cementing action of soil impregnated on the fibres of the cloth (LUND pers. comm.). The field control strips for the IBP work were inserted at the same time as test strips, so, contamination by soil organisms could have caused decay during storage and the resultant TS loss. In future, field control strips should be inserted and removed on the date of retrieval of test strips, any deterioration during storage would then be for the same period for both test and control samples. After retrieval, field control strips received the same treatment as test strips.

2.3. Variation between and within test samples and number of strips required

The standard errors of the means for ten strips mostly ranged from 0.7 to 2.0 with extreme values of 3.8 (see HEAL et al. 1974). A sample set of results is given in Table 2. Data shows coefficients of variation of 7—10 % for control pieces, and 25—40 % for test pieces, so that it is relatively easy to calculate the size of the standard error for samples of a given size. Some samples gave a higher or lower coefficient of variation. The variability of test pieces is largely due to biological heterogeneity in soil, which varies with sites. Given a preliminary field trial optimum numbers can obviously be calculated for any conditions but in general it is recommended that sample numbers should be maintained at no less than 8—10 strips. HEAL et al. (1974) give data for changes down soil profiles, and differences between sites.

2.4. Colour

Many reports in the literature (SIU 1951) refer to a variety of colours produced by specific organisms. Colours observed in strips were often characteristics of sites. They may depend on both microbial and soil characteristics, but no further investigation has been made. Observation of colour could possibly be used to demonstrate the presence of particular organisms, or activities, in a range of sites.

Table 2. The within-site variation of tensile strength at Pennine moorland sites

	TS in Kgm										Mean	S.E.
Control cotton	26.5	26.9	25.2	24.5	29.6	24.8	24.2	22.8	25.0	23.4	25.3	0.6
Limestone grass	19.8	20.0	12.9	13.0	16.2	18.1	12.2	24.4	22.0	13.1	17.2	1.4
Juncus moor	29.7	22.4	26.0	27.2	21.3	27.3	23.5	27.5	23.7	24.1	25.3	0.8
Blanket bog	27.6	21.0	12.8	20.8	28.0	18.4	25.2	21.0	28.8	28.8	23.2	1.7

Note. — The results for control pieces and for ten individual test pieces at 4—8 cm depth for each site is given.

3. An experiment on TS loss and weight loss with time

3.0. General remark

This was carried out to examine the relationship between TS loss and weight loss of the cotton material, since a good correlation would allow prediction of the weight loss of cellulose in the cotton from its TS and make possible more direct comparison with results for dry weight loss of litters. The standard method for treatment of cotton and measurement of TS was followed, with the exception that strips were only 9×9 cm in size.

3.1. Method

Three series of tests were set up: for two of these, soil was used as the rotting agent, and a cellulase enzyme was used for the third. Soils were collected from the upper layers of the profile of two sites in Cumbria, UK: Meathop Wood, Nat. Grid Ref. SD 434797, *p*H 6.8 and Whitbarrow (Durham Bridge Wood) Nat. Grid Ref. SD 474896, *p*H 4.9. They were passed through a 1 cm mesh sieve and placed in micro-plots consisting of open-ended sheet metal cylinders, ca. 35 cm diameter and 40 cm high, buried in the ground with the upper end ca. 5 cm above ground level and with 2 mm nylon mesh material over the base to exclude larger soil animals. 50 strips were placed vertically in two micro-plots for each soil type below a depth of approximately 5 cms. The enzyme rotted series was set up in the laboratory using a commercially prepared cellulase supplied by Glaxo Laboratories Ltd., Ulverston, and made up as 0.5 % solution in sterile 0.2 M citric acid-phosphate buffer at *p*H 5.0. Sodium-azide 0.5 % was added to prevent microbial activity. Aliquots of 50 ml were placed in sterile 1 litre conical flasks and one strip of cotton was placed in each of 100 flasks. The flasks were kept at room temperature.

Ten strips were sampled at each time interval (Table 3A) and in addition ten were used as controls for each series. Samples were removed over periods of up to 41 days during July—August 1970. Each strip was divided into two pieces, on one the tensile strength was measured, the other was cut to a piece 30 or 50 cm², dried at 120 °C and weighed to give the weight per unit area for each strip.

3.2. Results and discussion

3.2.1. *The relationship of TS loss or weight loss with time*

TS and weight both declined with time but TS showed a greater loss than weight (Table 3). Differences between mean TS and mean weights for the different sampling dates were highly significant. The results were used to test a number of models for the relationship between change in TS or weight with time. These included quadratic, exponential decay, asymptotic regression, sums of exponential decays and Maritz decomposition model (1957), but none gave a consistent improvement over a simple linear relationship. In practice, a simple proportional relationship was used (see p. 147) for prediction of TS loss over different time periods and was considered satisfactory over the centre range of TS loss.

In most work on biological decomposition, the loss is expressed as a proportion or function of the initial state and a curve is fitted. Such types of analysis have been used for cotton (Rogers and Wheeler 1940; Hueck 1965; Selby 1968). An obvious deficiency in these

Table 3. Decomposition of cotton with different rotting agents

A. Comparison of mean TS (kg) and mean weight (g/m²) at different times

	Enzyme			Meathop soil			Whitbarrow soil		
	Days	TS	Wt	Days	TS	Wt	Days	TS	Wt
(Control)	0	27.5	173	0	27.7	173	0	27.7	173
	1	24.3	165	15	23.0	168	15	25.8	172
	2	23.0	165	21	20.0	166	21	19.1	169
	4	22.7	164	29+	6.0	141	29	23.1	171
	6	20.5	160	31+	5.3	144	36	17.1	168
	8	21.2	162	36+	4.9	134	41	15.1	165
	10	20.2	160						
	13	19.1	159						
	22+	13.9	153						

Analysis of variance F ratio between dates

	Enzyme		Meathop soil		Whitbarrow soil	
	TS	Wt	TS	Wt	TS	Wt
All dates	29.3***	22.0***	61.6***	46.7***	12.1***	6.1***
df	7,72	7,72	5,54	5,54	5,54	5,54
Meathop 0—21 days only (omitting low TS data)			5.1*	6.4*		
df			2,27	2,27		

B. Linear regressions of mean TS on mean weight of cotton

Rotting agent	Weight =	r	df	F	Regression differences			
					Parallelism		Identity	
					df	F	df	F
Enzyme	127 + 1.64 TS	0.98	1,6	152***				
Meathop soil	146 + 0.96 TS	0.99	1,1	49 (p = 0.10)	2,11	29.5***	2,13	25.1***
Whitbarrow soil	157 + 0.58 TS	0.98	1,4	113***	1,5	8.1*	1,6	10.3*
Combined regression	149 + 0.81 TS	0.62	1,15	10***				

+ Low TS data, not used in linear regression analysis.

methods is that the initial state is itself a sample parameter which has to be estimated and is subject to error. Very precise estimates for control samples are therefore needed. It would be preferable to use models which acknowledge that the estimate of initial state is subject to error as are the test results for given periods of time.

3.2.2. *Relationship of TS loss with weight loss*

Because time was used in this experiment to give a number of levels of decomposition, the data were grouped. Within the data for particular sampling dates, only three regressions of weight on TS were significant, presumably because the range in TS was insufficient to establish any relationship. Analysis of the mean weights however showed that almost all the variability of mean weights could be accounted for by the regression on mean tensile strength. The results (Table 3 B) show a significant linear regression, at least for TS values between 14—28 kg, i.e. 0 to 50 % TS loss, for each rotting agent. The regression lines were significantly different ($P < 0.001$) in both parallelism and identity. The regression for the enzyme series accounted for a large part of this difference, the difference between regressions for the two soils being smaller. Data for TS loss and weight loss from Rogers et al. (1940)

Table 4. Linear regressions of TS on weight of samples

Site or rotting agent	Weight =	r	df	F		Regression differences			
						Parallelism		Identity	
						df	F	df	F
A.									
Sporocytophaga	278 + 0.71 TS	0.89	1,6	23***	)	1,11	3.6	1,12	1.3
Chaetomium	262 + 1.07 TS	0.97	1,5	9**	)	(p = 0.10)			
B.									
Dry meadow, Hardangervidda+	118 + 2.15 TS	0.57	1,45	22***	with wet meadow	1,116	8.9**	1,117	19.6***
					with Sike Hill, wet	1,69	12.1***	1,70	22.1***
Abisko, Sweden	124 + 1.83 TS	0.75	1,17	22***	with wet meadow	1,96	4.1*	1,97	0.1
Birch wood, Hardangervidda+	130 + 1.64 TS	0.54	1,25	11**	with Sike Hill, wet	1,49	5.3*	1,50	1.5
Wet meadow, Hardangervidda+	141 + 0.81 TS	0.52	1,71	27***					
Sike Hill, dry, Moor House°	144 + 0.70 TS	0.61	1,28	17***	No regression differences between these sites are significant				
Lichen Heath, Hardangervidda+	145 + 0.55 TS	0.34	1,40	5*					
Sike Hill, wet, Moor House°	149 + 0.51 TS	0.52	1,24	9**					
Combined regression (B)	135 + 1.09 TS	0.64	1,262	180***					

Note. — A. Using means from laboratory data of Rogers et al. (1940) (weight of cloth 322 g/m²). B. Using IBP field samples, individual data (weight of cloth 170 g/m²). ° United Kingdom, + Norway.

and HEAL et al. (1974), also gave significant linear regressions using TS values above 6 kg, equivalent to 70% loss (Table 4). The regression coefficient (b) showed a similar range to that in Table 3B (0.5 to 2.2) even for results using a different cloth. Significant differences between the b values were again found.

The regression equations for all these data showed some differences in the regression constant. This value depends largely on the weight of the cloth and varies in proportion to this property, but significant differences were also obtained between different rotting agents for the same cloth.

Analysis of all the IBP data, i.e. including TS data between 0—6 kg showed that a logarithmic curvilinear relationship (Log weight = Log a + b log TS) gave the best fit, as indicated by reduction of residual mean square. The a value in these regressions varied from 85 to 144 and the b value from 0.215 to 0.033 (i.e. in reverse order). SIU (1951) reported an exponential relationship between % tensile strength and % weight loss of fabrics under laboratory conditions.

All the results show that different rotting agents give significant differences in slope so, where prediction of weight loss from tensile strength is required, a calibration should be made for any particular soil or organism, either using a logarithmic relationship, or a linear relationship if TS measurements do not exceed 70% loss. The approximate slope of the regression of weight on tensile strength could then be determined and a suitable transformation derived. A strict comparison between TS and weight losses cannot be expected; weight loss represents an average measure of decomposition over the whole test piece, whereas the tensile strength is a measure of loss at the most decomposed part. It is also known (HALLIWELL 1968a), that early enzymic breakdown of cotton involves the formation of short fibres, so causing decrease in tensile strength prior to any weight loss. Data given by MILLS (1973) for different fungi inoculated on to filter paper show that 50% loss in tensile strength corresponded to weight losses of 4 to 20%. SELBY (1968) also found different regressions for individual and mixed components of the cellulase enzyme system, 50% TS loss corresponding to 1.5 to 4.5% weight loss. The relationship will therefore change according to the varying proportions of different organisms involved in cellulose decomposition, or of their constituent enzymes. Both TS and weight loss represent a degradation of the cotton material but TS loss can be expected to differ from dry weight loss, whether for cotton or for plant litter.

4. Conclusions

As an easily performed process, the cotton strip test gives an integrated index of activity on a cellulose substrate over a broad period and demonstrates changes down a soil profile at the same time. It thus allows a quick assessment of spatial and profile variations within sites, reducing the requirement for numerous replicated profile and seasonal tests. It can be used to show patterns of variability between sites prior to more detailed tests using more critical or specific methods to study particular pathways of cellulose decomposition. The method has now been used over a wide range of sites in cold temperate or polar regions where a further advantage was the ease with which the test material could be transported for distribution to sites and for return to one place for processing. It has given biologically significant comparisons between sites, including variation in the patterns of change down soil profiles (HEAL et al. 1974). It is recognized that the method is selective and represents a different mode of attack to that of dry weight loss, but it is considered to indicate a potential of the soil to attack cellulose under field conditions.

For comparisons with the weight loss of litter, the weight loss of cotton can be predicted from the relationship with its TS loss, the regression being determined for any particular site, because regression coefficients for individual sites may be significantly different. Chemical and physical features of decomposing vegetation will affect relationships between the pattern of variability between sites shown by the method or by results for dry weight loss of litters. Results obtained by the two methods are compared in HEAL et al. (1974) and were

broadly similar for individual plant litters. However, HARTLEY, JONES and WOOD (1973) have demonstrated variability in the order of results for different fungal culture filtrates acting on cotton cellulose or on a grass cell wall preparation. They show that different enzyme components account for some differences, so, variability under the mixed organism conditions of soil may be less pronounced than that shown by pure cultures or enzymes. JONES and HAYWARD (1975) show that increased, but more similar, activity was shown by two fungal enzymes when herbage received a pre-treatment with pepsin, indicating that there is some effect due to ancillary cell wall constituents for cellulose within-plant material. Taking these effects into account, the method may help in isolating the effects of soil properties from those of litter quality, and HEAL et al. (1974) emphasize the importance of litter quality in determining the decomposition rate of plant litters.

The method is suited for the detection of major long-term effects of chemical treatments or land-use changes (SPRINGETT 1970) or for preliminary comparisons of a wide range of sites as in the IBP studies (HEAL et al. 1974). It could also be used to test the effect of added nutrients on soil activity.

In any future use of the method, some changes are recommended and further work is required on some aspects, i.e.:

(i) A new source of cloth and with more uniform characteristics the Shirley soil burial test fabric, has now become available, and can be purchased from the Shirley Institute, Didsbury, Manchester, M20, 8RX.
(ii) More control strips should be used and two sets are required
 (a) cloth control to determine initial TS of the cloth
 (b) field controls to estimate errors resulting from insertion and retrieval, these to be inserted and removed on the retrieval date for test strips.
(iii) A model for weight and TS losses with time is needed, together with more information on patterns of seasonal changes, to improve site comparisons.
(iv) More information on the causes of variation in the relationship between TS loss and weight loss could assist interpretation in some cases. The varying relationship may indicate varying components of cellulose breakdown in different sites.
(v) Further investigation of the affect of abiotic factors on TS loss in particular soil conditions.

The use of the method has been described and discussed in some detail because it is being used in a number of studies and because this type of method could well be extended for use with other substrates, e.g. HAIDER and DOMSCH (1969), using TS or other measurements, and where similar problems could arise.

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6. Summary · Zusammenfassung

Strips of cotton material, inserted vertically in the soil have been widely used in field studies in the Tundra Biome of the International Biological Program, to assess the potential of organisms to attack cellulose under particular soil and climatic conditions.

The method and its use are described and discussed in detail. This simple field test, is considered to give an integrated index of activity over a period of time, for any soil profile, for use in the initial stages of site comparisons or investigations on the effect of management and land-use changes.

Die Verwendung von Baumwollstreifen zum Nachweis der Zelluloserotte im Freiland

Baumwollstreifen, senkrecht in den Boden eingesetzt, wurden allgemein bei Feldstudien im Tundra Biome des Internationalen Biologischen Jahres verwendet, um die Fähigkeit der Organismen zu messen, Zellulose unter bestimmten Boden- und Klimabedingungen anzugreifen.

Die Methode und ihre Anwendung werden beschrieben und detailliert besprochen. Diese einfache Feldstudie soll einen integrierten Index der Aktivität über eine Zeitspanne für alle Bodenprofile geben. Sie kann in den Anfangsstadien von Bodenvergleichen oder zu Untersuchungen des Einflusses der Bewirtschaftung und Veränderungen in der Bodennutzung angewendet werden.

7. References

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